THE EXPLOSIVES ENGINEER

FORE-RUNNER OF PROGRESS IN MINING-QUARRYING & CONSTRUCTION

JANUARY-FEBRUARY · 1959

VOLUME 37 · NUMBER 1

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Gardner-Denver Rotary 600

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THE EXPLOSIVES ENGINEER

Forerunner of Progress in Mining, Quarrying, Construction

Perhaps one of the most intricate heavy-construction jobs now in progress is the work being done at Muscle Shoals near Florence, Alabama, by the Tennessee Valley Authority. Among other items, the plans call for the building of a new lock for a 100-ft. lift which will replace two tandem locks now providing a 90-ft. lift and a third lock with a 10-ft. lift. The channel leading to the locks also will be straightened so that entry to the locks will be much less difficult than at present.

A delicate blasting job, and one that required the utmost in engineering and blasting skill, was the driving of tunnel cuts 19 by 27 ft. through the old dam without disturbing the stability of this structure. To make the job more difficult the aggregate for the old dam had been poured over 30 years ago and contained many large boulders.

J. E. McClinton's article, beginning on page 5, describes the overall Wilson Dam project and places special emphasis on the delicate blasting work involved.

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In this issue we proudly present a lithographed brochure paying tribute to The Moles—that hardy breed of men engaged in the heavy-construction industry. These are the builders of the tunnels, the hydroelectric dams, the bridges, roads, and other projects requiring the vision, stamina, imagination, and engineering skill characteristic of The Moles.

The stirring text, by Ashworth Burslem, captures in blank verse the spirit of The Moles and their approach to the problems of their craft. The pencil sketches by John Moll, well-known painter and illustrator of marine and historical scenes, dramatically portray the immensity and technical details of The Moles' work far and wide. "A Salute to The Moles" begins on page 13.

EDITORIAL STAFF: James J. O'Neill, *Managing Editor;* Thomas E. Miller, *Contributing Editor;* Gertrude A. Donnelly, *Associate Editor;* Edward L. Grant, *Art Editor;* Howard B. Dickson, *Production Manager;* Charles E. Rabenold, *Advertising Manager;* Montgomery R. Budd, *Director*

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CONTENTS

John Bruce Bonny—*a photograph* 2
John Bruce Bonny—*a biography* 3
Editorial 4
Delicate Blasting on Wilson Dam 5
By J. E. McClinton
A Salute to The Moles 13
By Ashworth Burslem—
Illustrations by John Moll
Chute-des-Passes—A Gigantic Construction Project 21
By Robert E. Dyment
California's Carquinez Bridge Freeway Project 25
By David B. Jacobson
The Beavers Awards 28

Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

Despite the extreme cold encountered in the bush country of northern Quebec there is great activity as Aluminium Limited's gigantic hydroelectric plant nears completion. Many superlatives could be used to describe this undertaking. The following facts, however, will convey an idea of the size of the job: the hydroelectric units, of which there will be five, are each capable of producing 200,000 hp.; the underground powerhouse to headquarter these big generators requires the excavation of 85,129 cu. yd. of rock for a chamber 465 by 70 by 70 ft.; in addition, there will be about 10 miles of tunnels—6 miles of 34-ft.-diameter power tunnel and 9,000 ft. of 48-ft.-diameter tailrace tunnel. The three adits that will total 8,774 ft. in length make up the remainder of the underground mileage. About 10,000,000 lb. of dynamite will be used to blast out the underground tunnels and chambers.

More details about this Canadian job will be found in the article by Robert E. Dyment starting on page 21.

° ° °

Motorists and truckers using U. S. Route 40 between San Francisco and Sacramento no longer will have to travel over a winding, twisting, narrow road. The new highway and enlarged bridge over the Carquinez Straits will eliminate a traffic bottleneck that has long plagued travelers between these two cities.

An interesting phase of the modernization program is the Carquinez Cut—the man-made canyon that required the removal of 8½ million cu. yd. of earth and is ¾ mile wide at the top and more than 300 ft. deep at its deepest point, making it the biggest highway cut in the United States.

In the article starting on page 25 David B. Jacobson outlines the work details on this project.

JOHN BRUCE BONNY

John Bruce Bonny

VICE PRESIDENT AND GENERAL MANAGER

MORRISON-KNUDSEN COMPANY, INC.

A Biography

JOHN BRUCE "JACK" BONNY, the globe-circling vice president and general manager of Morrison-Knudsen Company, Inc., has his headquarters and home in Boise, Idaho, but he spends more time in Africa, Asia, and the South Pacific guiding this world-wide heavy-construction company.

In 1952 he began shuttling between Idaho and French Morocco, as chairman of the operating committee and top administrator of a group partnership sponsored by his company, and known as Atlas Constructors, which was formed to build a well-known chain of United States air bases.

As the Moroccan work tapered off, Jack began shuttling to Iran, the scene of another joint venture, that of Morrison-Kaiser-Oman, a partnership formed to execute an $80 million contract with the United States Army Corps of Engineers for military bases and airfield for the Iranian Government at nine different locations. At the same time he looks in on the construction of the Karadj Dam and other work for the Government of Iran which M-K International is doing. Iraq, where M-K Limited recently finished a hundred-mile highway between Basra and Amara, called him often. This highway job continued right on through the revolution of July, 1958, and M-K obtained the acceptance of the work from the new government a month ahead of the contract time. Less spectacular, but equally difficult, jobs have been carried on at the same time under Jack Bonny's watchful eye in Turkey, Pakistan, Indonesia, and other parts of the world.

It is partly Jack Bonny's organizing ability that is responsible for the accomplishments of M-K in getting jobs done ahead of schedule. His solution for construction problems is always based on a thorough, first-hand acquaintance with the job to be done, and the problems to be met, which explains his seven-league-boot approach to the job of general manager.

In this country, Bonny stops down frequently in Cleveland, Ohio, the headquarters of The H. K. Ferguson Company, the industrial engineering and building company acquired by M-K in 1950, of which he is chairman of the board. This sort of supervision takes a lot of flying. Bonny flies over 200,000 miles a year on this continent alone. He is a licensed pilot, and often flies the company's DC-3 assigned to him.

Jack was born February 8, 1903, in San Francisco, California. His grandfather was a pioneer builder of the original Sacramento levee system. His mother was a native of San Francisco, and his maternal grandfather established one of the pioneer jewelry companies there.

After graduating from the University of California in 1925 with a Bachelor of Science degree, Jack joined the Derbon Construction Company, a partnership construction firm. Five years later in 1931 he joined the M-K organization, and after a year in Seattle, he became M-K's Los Angeles district manager. In January, 1943, he became a vice president of the company; a year later, a director; and in 1947 he assumed his present duties of general manager of the expanding M-K operations, with headquarters in Boise.

Two developments of the M-K organization Jack Bonny has sponsored are the expansion of the M-K accident-prevention program, and the establishment of the company-wide mechanic training courses. The scope of the general manager's job may be gleaned from the fact that in 1958 M-K had more than 200 separate contracts in progress in the United States and eighteen foreign countries, and for the execution of these Jack Bonny kept in close touch with twenty-four subsidiaries as well as those of the parent corporation.

Such a continent-hopping job does not give a man much time for hobbies, but Jack says he now and then plays a poor game of golf. His first love is fishing for the giant marlin swordfish in Mexican waters with light tackle, and he loves to go after king salmon and the huge rainbow trout with a light rod in Alaskan waters.

He lives at 4902 Roberts Road, Boise, with his wife, Marie, and their two children, Jan and Robert.

Jack Bonny has demonstrated his ability to sell, organize, and direct almost any kind of construction job, big or small, and he has the quick-thinking, fast-acting personality to make a success of it. He believes that the construction business is the most important business in the world, for he sees in it, not merely new roads and new buildings, but a molding of the lives of future generations for the well-being of mankind in all countries.

Editorial

Steel to the Man in the Street

The steel industry has done an extraordinarily fine job in acquainting the public with the importance of that metal. The American Iron and Steel Institute and the individual steel companies, in their public relations advertising, have concentrated on explaining to America the universality of steel.

Newspapers, magazines, movies, and television have carried the story of how much steel is relied upon by Americans to make their lives interesting, healthful, comfortable, cultivated, and amusing. Figures on the per capita consumption of steel have been reported to convince America that steel really is consumed in substantial quantities by United States citizens. The American housewife is portrayed using steel in ways which no doubt many of them had never before been aware of. Consumer products for the dowager and the sweet young thing have been pointed out; feminine necessities from bobby pins to lorgnettes contain steel.

Similarly the red-blooded, active American has been pictured, surrounded by the steel products he enjoys day in and day out, in very striking and convincing advertisements of consumer uses for steel. The American male, we see, uses steel in his fishing rod, golf club, radio, hi-fi set, alarm clock, auto, and so on for almost everything he touches in sports, business, eating, sleeping, and drinking. Surely most literate Americans must be aware of the omnipresence of steel by now.

We would not presume to tell the steel industry how to conduct its advertising campaigns, but we do believe that great emphasis should be laid on the remarkable progress that has been made by the industry in perfecting alloys for special purposes. Steel companies have not been silent about their alloys, of course, and have published articles in their house magazines, and their technical ads are filled with the qualities obtainable in their alloys.

But to the man in the street, and the lady by his side, we suspect that steel is steel, and that at present little is known about alloys except, perhaps, the housewife realizes that some kitchen knives are stainless. Yet how much further the industry has gone to adapt its products to the particular needs of consumer goods. The very hard, tough steels do a great job for the average man, of which he is probably unaware: they make hand tools, gears, garden tools, and socket wrenches. Most of us take these things for granted without realizing the skill of the metallurgist who has produced a custom-made metal for us.

High-nickel alloys resist high temperatures such as the automobile engine develops, yet the average American probably takes his engine for granted without thinking, even when the engine gets hot, that alloy steel makes this possible.

The steel industry in America has much to be proud of in its development of alloys for special purposes. It makes a marvelous story of progress of American industry, one that the average American would admire and respect. We are confident that the continuing promotion plans of the steel industry will emphasize this aspect of steel in our daily lives.

Watch Your Detonators

The Institute of Makers of Explosives carries on a constant campaign to warn children of the dangers of playing with blasting caps. Probably few explosives consumers are unaware of this warning, so widespread has it been carried by the wholehearted cooperation of the schools and other organizations working with our youth.

The users of explosives can help this work in two ways. First, they can persuade their local schools, newspapers, radio and TV stations to carry the warning issued by the IME. Second, they can conduct a campaign of their own to see that no caps of theirs fall into the hands of children.

Each year the Institute issues a poster designed for explosives users, on the back of which is this message: "It is obvious to all those familiar with explosives that if the blasting caps could be kept out of the hands of children, there would be no accidents to the youngsters. The Institute, for that reason, has prepared a poster on the reverse side of this sheet to caution all users of caps to take care in accounting for these detonators. All caps taken from the magazine should be accounted for at the end of each day, and caps in storage kept under lock and key.

"We feel sure we can enlist your support in this campaign to place the poster at a point where it will be most likely to caution the users of blasting caps to remember the children.

"We trust you will be able to put the poster on your magazine door or some other conspicuous place where all those who have access to your caps will see it."

Let's not relax our vigilance. The eyes of our children depend upon it.

CANAL CROSSING: Florence Canal deepening is proceeding in the dry behind cofferdams which hold back the waters of the temporary canal cut across Patton Island for use of river traffic while the old channel is being deepened and realigned, and the new lock built. Wilson Dam, Lake Wilson behind it, and work on the new lock can be see at upper right.

Delicate Blasting on Wilson Dam

Tennessee Valley Authority blasts through Alabama's Muscle Shoals Dam to construct a new lock for a 100-ft. lift which will eliminate traffic bottleneck

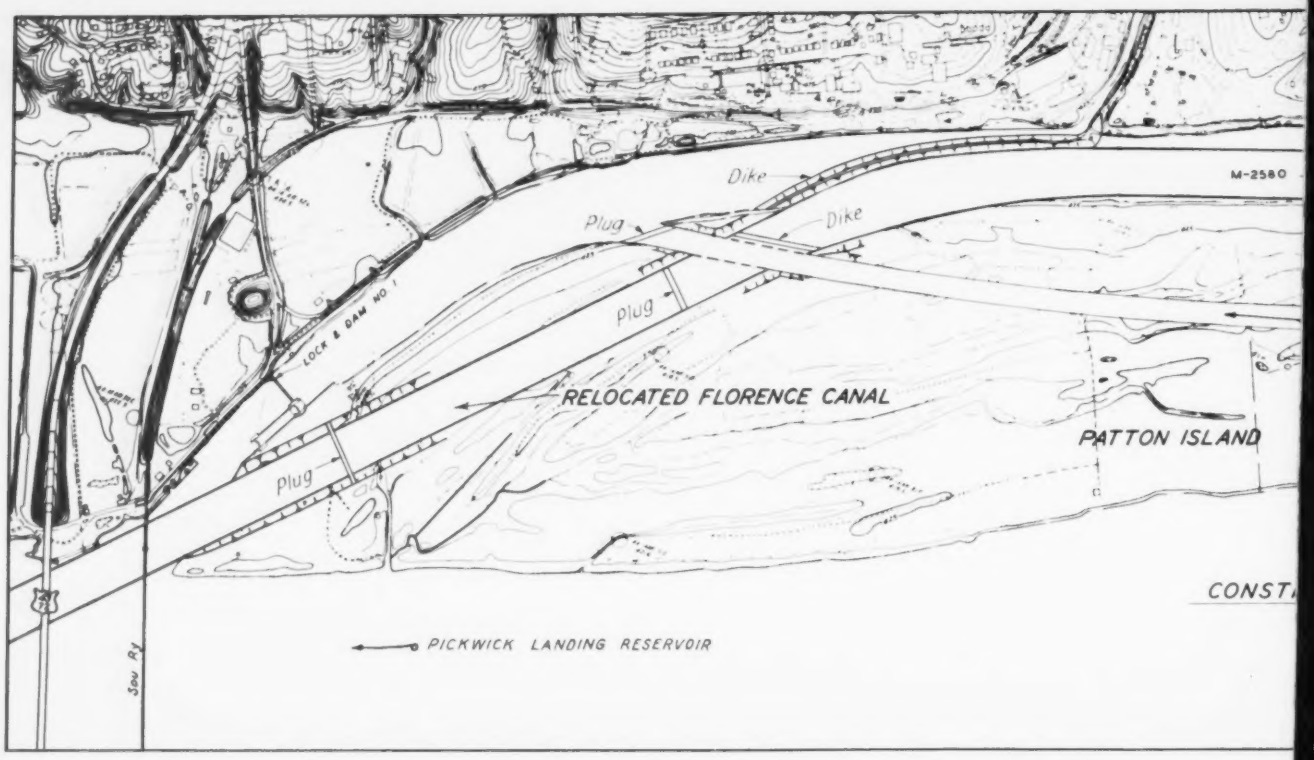
J. E. McCLINTON*

At Muscle Shoals on the Tennessee River the Tennessee Valley Authority is engaged in one of the most elaborate and intricate heavy-construction jobs now being carried on anywhere in the country. A new lock for a 100-ft. lift is being constructed to take the place of two tandem locks now providing a 90-ft. lift and a third lock downstream with a 10-ft. lift.

At Muscle Shoals near Florence, Alabama, the Tennessee River has become famous in the history of the country for the navigation difficulties it has thrown in the way of the traveler ever since De Soto used it for his expedition to the West in 1540.

The Tennessee at this point drops nearly 100 ft. in 27 miles. The present lock chambers, constructed in 1925-27, have become inadequate to handle the river traffic efficiently. Set close to the side of the river, the locks not only cannot accommodate the modern large tows, but also make navigation difficult because of the curves involved in both the upstream and downstream approaches. Some tows cannot be

*Hercules Powder Company
Birmingham, Alabama



passed through the three locks in less than 12 hours.

The facilities now consist of the double-lift lock at the dam, the Florence Canal 2¾ miles below the dam, and a single-lift lock and dam at the downstream end of the canal. The upper and lower chambers of the double-lift lock are 60 by 292 ft. and 60 by 300 ft., respectively. Lock No. 1 at the downstream end, with a lift of 10 ft., has a lock chamber 60 by 298 ft.

Funds for the design and construction of the new facilities were appropriated in 1955 and 1956, and work began in July of the latter year. Initial operation of the locks is scheduled for September, 1959, and completion of the entire project, estimated to cost $35 million, is expected in August, 1960.

Larger Chamber Specified

The new lock chamber in the existing dam will be 110 by 600 ft. and is entirely downstream from the dam. The upper gate is of the submerged-lift type. The lock walls extend downstream 800 ft. and below the river wall runs a guide wall 635 ft. long. A double-leaf-miter gate 117 ft. high is being installed at the lower end.

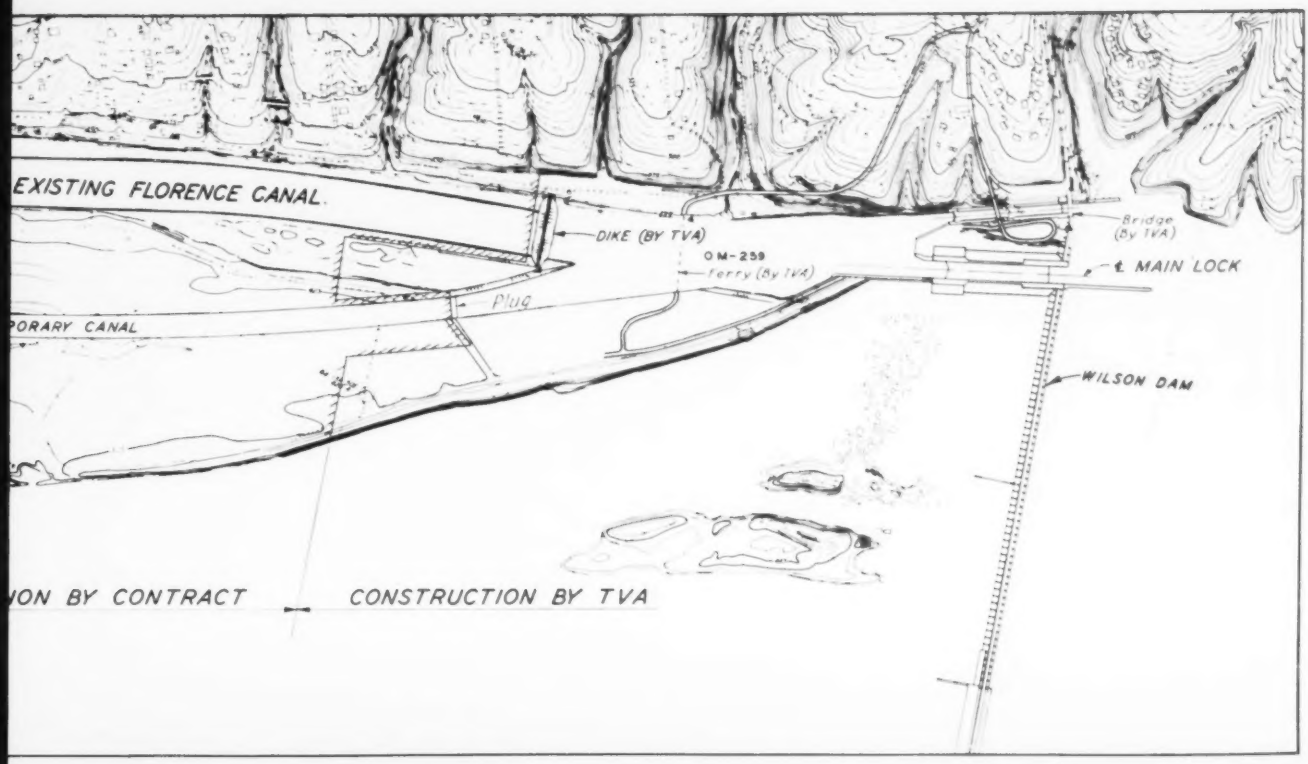
The volume of water required to fill the 100-ft. lift chamber is 54,000,000 gallons, and the filling time will be 16 minutes. To supply the 20,000 c.f.s. of water to fill the chamber two 15 by 15-ft. culverts extend the length of the chamber in each wall, terminating upstream at bellmouth intakes 15 by 23 ft. in the dam face, while downstream they make a 90° turn to discharge into the dam-spillway channel. Filling can be speeded by lowering the upper gate to spill water into the chamber, and emptying will be speeded through ports under the lower gate. In contrast with the hours consumed in the present lock, the full locking cycle will average 45 minutes.

Not only will the locking time be cut by the new lock, but the canal will be straightened to speed up traffic. To bring a long and heavy tow into the old lock was a difficult and tedious job of navigation because of the sharp bends in the sailing line into and out of the chamber. The 10-ft. additional lift at Wilson Dam provided by the new lock permits the elimination of the downstream lock, thus speeding up the passage. To do this the lower tandem-lock chamber (which will be kept in standby condition) and the canal must be deepened by 10 ft.

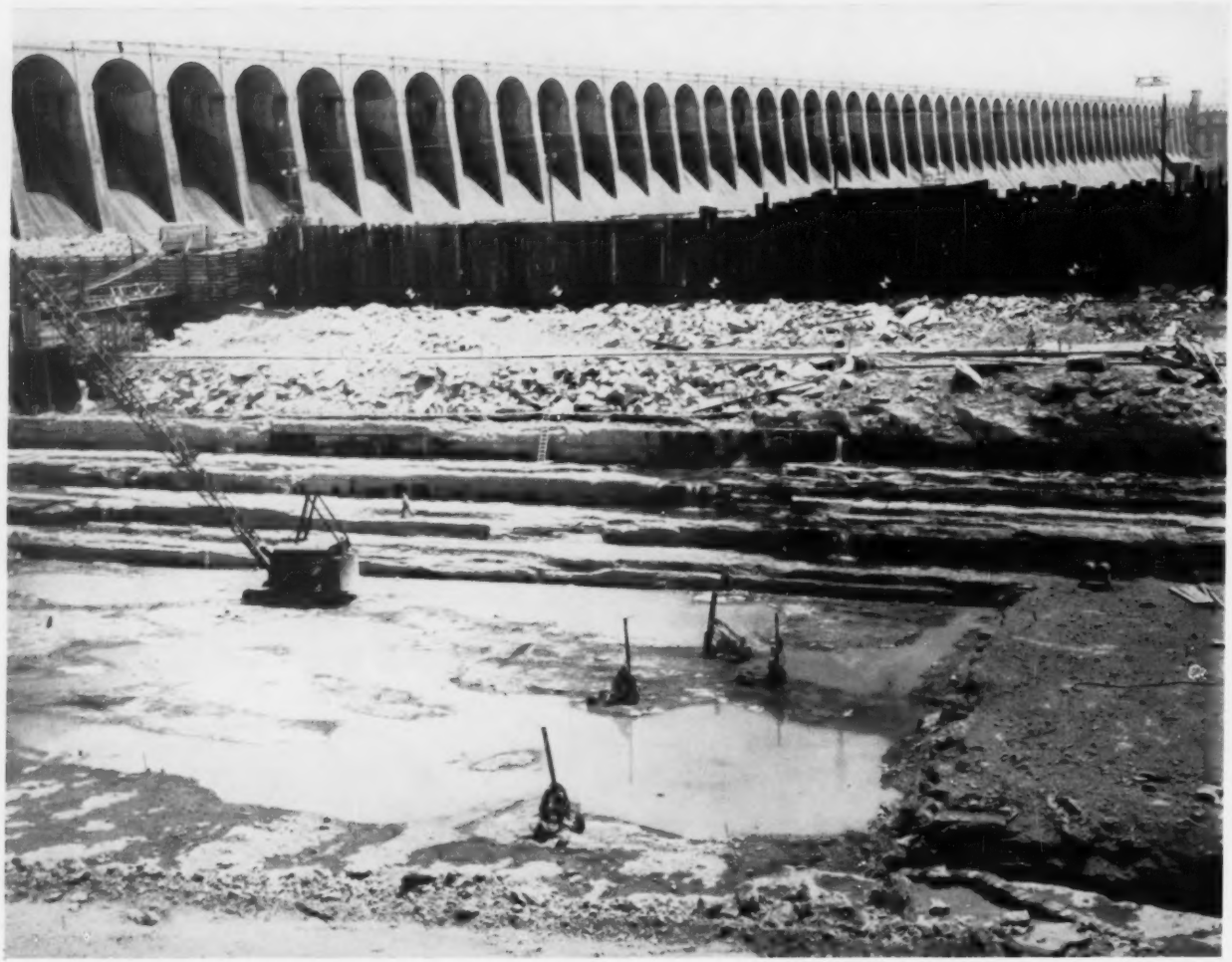
In place of the drawbridge across the old lock, a high-level highway bridge will cross both the new and the old locks to do away with traffic interruptions on both the highway and the river.

The TVA is carrying through the involved construction of the new facilities with very little interruption to traffic on the roadway across the dam, and almost no interruption to navigation. It is accomplishing this feat by an extraordinary canal detour provided through a temporary channel. By means of dikes and cofferdams, river traffic has been detoured, and much of the channel construction has been done in the dry. The principal jobs involved are construction of a new lock chamber, extensive spillway alterations in Wilson Dam, construction of the temporary canal for the use of river traffic while the present channel is being deepened and realigned at the downstream end, construction of the high-level highway bridge, deepening of the present lock chamber to permit the existing tandem locks to function as an auxiliary unit without the additional 10 ft. of lift now provided by the downstream lock No. 1.

The new 110-ft.-wide lock placed in



NEW LOCK: Bulldozers, shovels, and trucks dig out broken rock from the chamber area. Channels have been cut for the filling and emptying culverts and other waterways, and work has begun on the tunnel for the intake culvert being driven through the old dam.



CHAMBER AREA: Here is foundation of the new lock with the downstream face of the dam, with cofferdam in background. The very hard chert in the new lock area caused difficulty in drilling and blasting. Seepage from the river behind the cofferdam necessitated constant pumping.

the existing dam eliminates eight spillway gates in the old dam, reducing their number from 58 to 50. Upstream river regulation by other TVA installations and the construction of additional power units at the dam have made possible this reduction in the spillway capacity of Wilson Dam.

Temporary Channel

To permit continuation of the river traffic with a minimum of interruption, and to make possible much of the deepening of the channel in the dry, TVA provided a temporary channel across Patton Island, which lies between the permanent Florence Canal and the river. An elaborate timing schedule of cofferdam changes and temporary and permanent dikes was required. The temporary channel struck no rock, so that no blasting was needed in this part of the work. This excavation and the deepening of the Florence Canal were done by Massman Construction Company of Kansas City, and Farrell Construction Company of Memphis, Tennessee, and Brinkley, Arkansas. The rock excavation was subcontracted to the Clarkson Construction Company of Kansas City, Missouri.

Excavation in the main lock area was done by TVA and involved some unusual rock. Just below the dam a great many large, loose boulders, some reaching a size of 200 tons, had been displaced and had rolled down into the river bed by the force of the dam-spillway discharges and were deposited in piles. Many of these boulders had to be reduced in size by blasting for loading by power shovels.

Hard, Dense Chert

The solid rock formation in the main lock area is a shaly limestone streaked with dense chert or flint, a substance so hard that it resulted in severe wear to drill bits, track pads, and shovel dipper teeth. The horizontal layers of the formation cut across with vertical seams, many mud-filled, made drilling and blasting difficult.

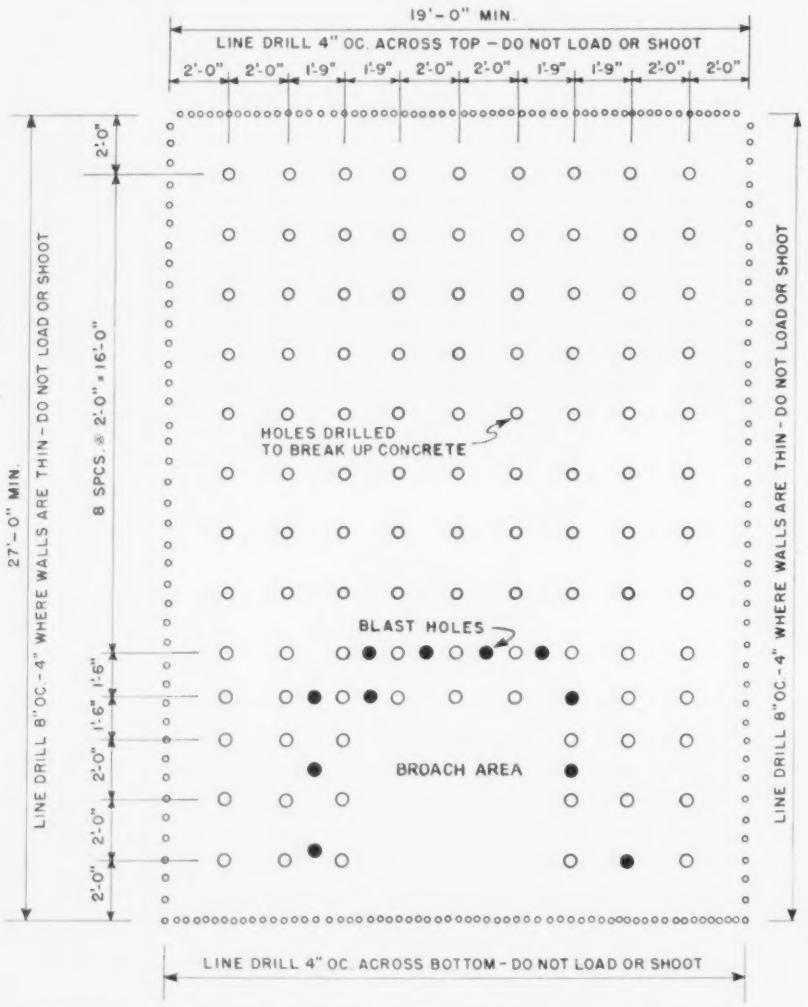
Work on the solid rock began at the downstream end with 21 wagon drills mounting Ingersoll-Rand X-71 drifters. Air for the drills was supplied by an Ingersoll-Rand 2900-c.f.m. compressor and a Sullivan 3100-c.f.m. compressor, both of which furnished air for the whole job. The extreme hardness of the rock forced the use of 4-point, 2-in. bits with tungsten-carbide inserts, which were satisfactory but expensive because of high breakage of drill steel in the more seamy sections. Drill holes were put down on 5-ft. spacing to an average depth of 12 ft. Holes were loaded with Gelamite® 2, 1¼ by 12 in.,

TUNNEL FOR INTAKE CULVERT: Tunnel face shows line-drilling on top, bottom, and sides, and holes in the face to break up concrete, as blast hole is put down by the driller. The line-drilling indicates the approximate finished dimensions of the culvert after the tunnel is lined with concrete to facilitate the flow. In this area, blasts were small so as to avoid damage to permanent installations.

and the loading factor was approximately 0.75 lb. per cu.yd. Primacord* with delay connectors was used as the detonating agent.

Waterways and excavation limits were line-drilled to preserve neat lines and prevent backbreak. Two-in. bits were used for this drilling and for the blast-hole drilling. Spacing varied from 4 to 6-in. centers, depending upon the character of the rock. Along the lines adjacent to the dam a complete broaching job was done to protect the old concrete.

Removal of material from the lock area was done in three stages by shovels, draglines, and clamshell. In the initial stage, loose boulders and earth were removed to solid rock ahead of the drilling and blasting. This overburden, totaling approximately 100,000 cu. yd., was removed by one 38B Bucyrus-Erie shovel with 1½-cu. yd. dipper and one 3500 Manitowoc shovel with a 2½-cu. yd. dipper, both on two shifts per day. Six to ten Euclid 10-cu. yd. end-dump trucks hauled the material, the number of trucks used depending upon the length of haul to the disposal area on Patton Island.


19'-0" MIN.
LINE DRILL 4" OC. ACROSS TOP - DO NOT LOAD OR SHOOT
2'-0" 2'-0" 1'-9" 1'-9" 2'-0" 2'-0" 1'-9" 1'-9" 2'-0" 2'-0"
2'-0"
8 SPCS. @ 2'-0" = 16'-0"
27'-0" MIN.
LINE DRILL 8" OC. - 4" WHERE WALLS ARE THIN - DO NOT LOAD OR SHOOT
HOLES DRILLED TO BREAK UP CONCRETE
BLAST HOLES
BROACH AREA
2'-0" 2'-0" 1'-6" 1'-6"
LINE DRILL 8" OC. - 4" WHERE WALLS ARE THIN - DO NOT LOAD OR SHOOT
LINE DRILL 4" OC. ACROSS BOTTOM - DO NOT LOAD OR SHOOT

DRILLING PATTERN FOR INTAKE CULVERT TUNNELS: Blast in culvert tunnel put through old dam showing location of blast holes for the initial broach shot. The 11 holes were each loaded with 2½ cartridges of Gelamite 2, in two charges, one at the back of the hole and one at the front, and primed with two delay caps in each hole, ranging from first to fifth delay. This blast used 13⅜ lb. of dynamite and brought down 5 cu. yd. of concrete. The culvert break line was line-drilled on the top, bottom, and sides to avoid damage to adjacent concrete, and drill holes were drilled at approximately 2-ft. spacing. Line-drilling used 2½-in. holes on 4-in. centers top and bottom and 8-in. centers on sides; where walls were thin, spacing was reduced to 4 in. Line-drilling holes were 10 ft. deep and blast holes 4 to 6 ft. deep.

Following the stripping, the solid rock was taken out to elevation 394, which is the maximum design rock elevation within the lock area. One 2½-cu. yd. Bucyrus-Erie 54B and one 2-cu. yd. Bucyrus-Erie 51B were used. This excavation reduced the rock within the area to approximately elevation 394. Finally, material was removed for construction of the filling and emptying culverts and waterways. The main area was excavated to elevation 380 and some areas taken down to elevation 370 in lifts of 7 to 10 ft. using mainly power shovels. As the waterways were too narrow for the shovels to work in, they were dug with a 60-ton Osgood equipped with a 2-cu. yd. dragline bucket. Two Caterpillar D-8 tractors with bulldozer mountings cleaned and maintained roadway ramps. A third Caterpillar bulldozer maintained the spoil area. Slightly over 200,000 cu. yd. of rock was removed.

Water seepage through rock seams from the adjacent cofferdam and from the old Wilson lock was a serious problem. To meet it four sumps were blasted into the rock along the river side of the river lock wall, the deepest of these taking water from the lowest excavated areas. Nine 14-in. and 16-in. electric motor-driven pumps handled all seepage, four being used most of the time, but all nine were pressed into service in flood season.

Delicate Blasting Problem

Construction of the two culverts that supply water to fill the lock chamber presented a most delicate blasting problem. Each culvert required the driving of tunnel cuts 19 by 27 ft. through the old dam to provide a culvert 15 by 23 ft. after lining with concrete to facilitate the water flow. This blasting had to remove the dam concrete without disturbing the old structure, and the aggregate for this concrete, poured over 30 years ago, contained huge boulders, some several feet in diameter, increasing the complexity of the drilling and blasting. About 16 ft. of the concrete on the downstream face was removed by an open blasting procedure, but the re-

*Reg. U. S. Pat. Off. by The Ensign-Bickford Company

OLD AND NEW LOCK: Old lock continues in use while the new lock at center is built. Existing lock and approach are spanned by access bridge and conveyor for concrete mixing plant.

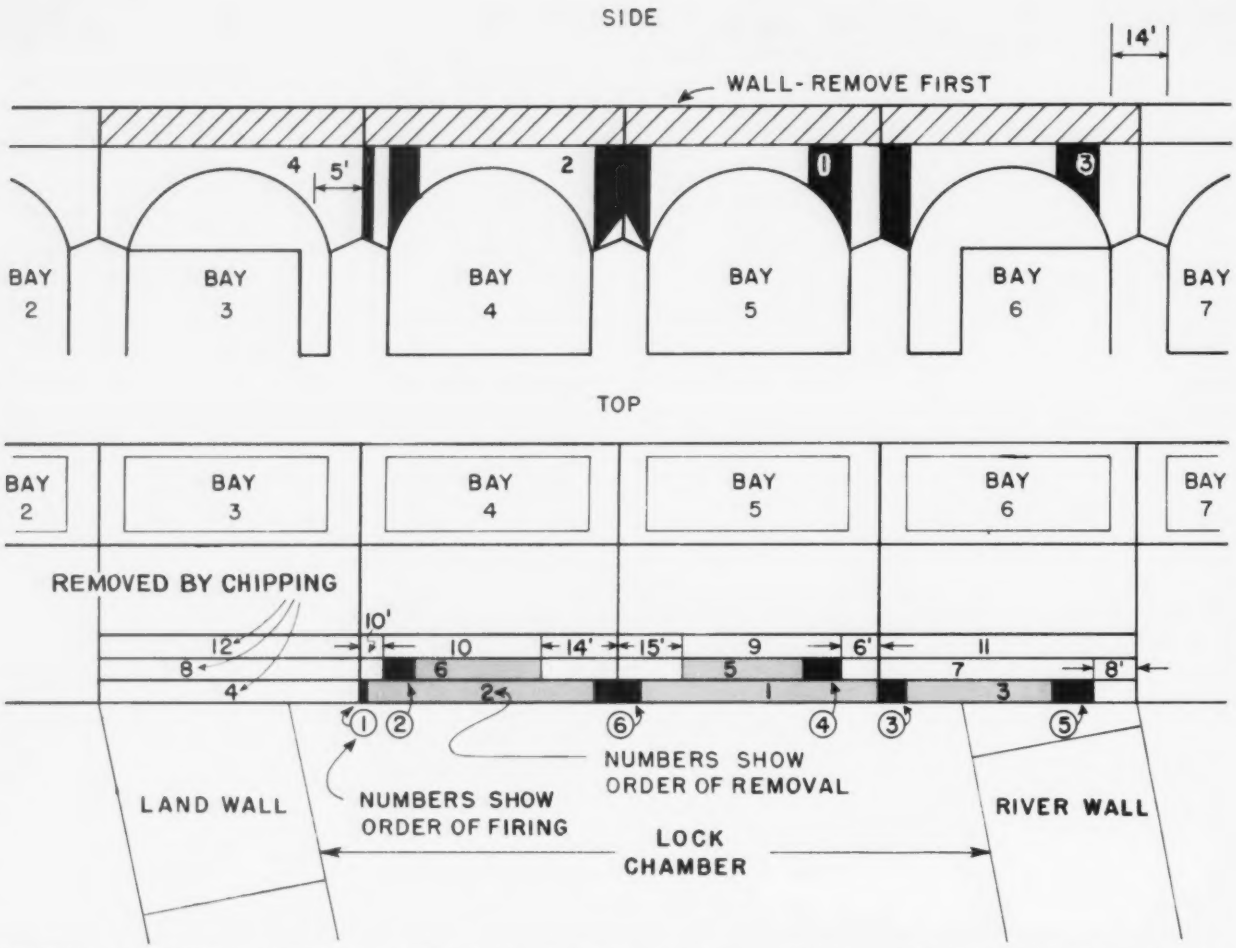
REALIGNED CANAL: Elimination of downstream lock and dam permits realignment of Florence Canal. River traffic will be able to clear railroad and highway bridges more easily.

LINE-DRILLING: TVA line-drilled at toe of the dam to prevent damage to existing structure from blasting in the lock chamber area. The rock encountered was a very hard chert.

LOCK CONSTRUCTION: New chamber area under construction showing concrete forms, culvert channels, and waterways cut in rock. Approach to the old lock is at the top of photograph.

MITER BLOCKS: Shown here are upper miter blocks and removal of the concrete from the tunnel for intake culverts. Possibility of damage to old dam required careful blasting.

ROCK EXCAVATION: Shovels at work on TVA portion of canal. The Authority reserved for itself the deepening of the approach to the new lock. In this area, many large boulders necessitated blasting.



REMOVAL OF CONCRETE ARCHES AND PIERS: Construction of the new lock required the removal of a section of the old dam. Bays Nos. 3, 4, 5, and 6 are being removed. Diagram shows pattern for a typical blast of 28.75 cartridges of Gelamite 2, 1¼ by 8 in. weighing 11.5 lb., which brought out 4.5 cu. yd. of concrete. Delay caps one through ten were used. An area of the pier or arch approximately 4 by 6 to 8 ft. would be drilled with six holes, the depth varying with the position of the shot. Adjacent arches were checked closely after each shot, for possible damage, and falling-pin vibration tests were made on the sidewalk above the piers to determine extent of vibration. Sections Nos. 4, 8, and 12, originally planned to be blasted out, were not removed with dynamite because of fresh concrete placed in the lining of the intake culvert tunnel below that arch. Concrete in Bay 3 was removed by line-drilling, chipping, and wedging. Concrete in the tunnel on the river side had aged enough so that blasting would not damage it. The utmost care and engineering skill was necessary in removing these arches and piers.

mainder of the 42-ft. cut required more care.

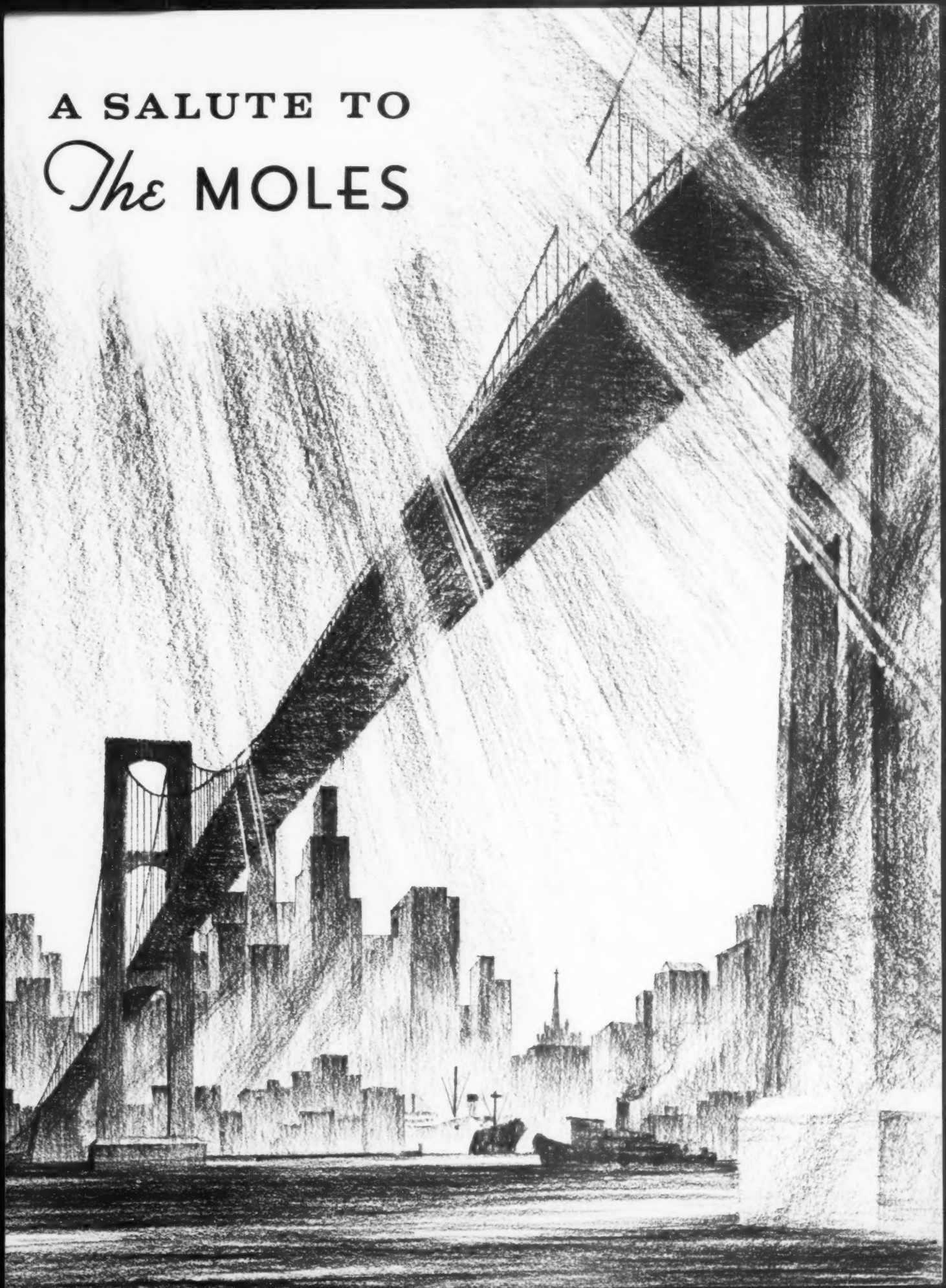
Concrete for the upper gate sill was placed to approximately the final elevation, and the lock walls to above lake level before tunneling was done. TVA made use of a 200-ton floating bulkhead, 46 by 74 ft., constructed by the Authority to seal off Lake Wilson during culvert tunneling and concreting. It is a 3-ft.-deep, all-welded cellular structure with sides and bottom shaped to fit against the upstream face of the dam. The bulkhead was positioned by flooding one end to bring it into an upright position, pulled over to the dam face, and the water behind it pumped out, the spillway gate removed, and the remaining water pumped out so that the lake water pressure forced a tight seal.

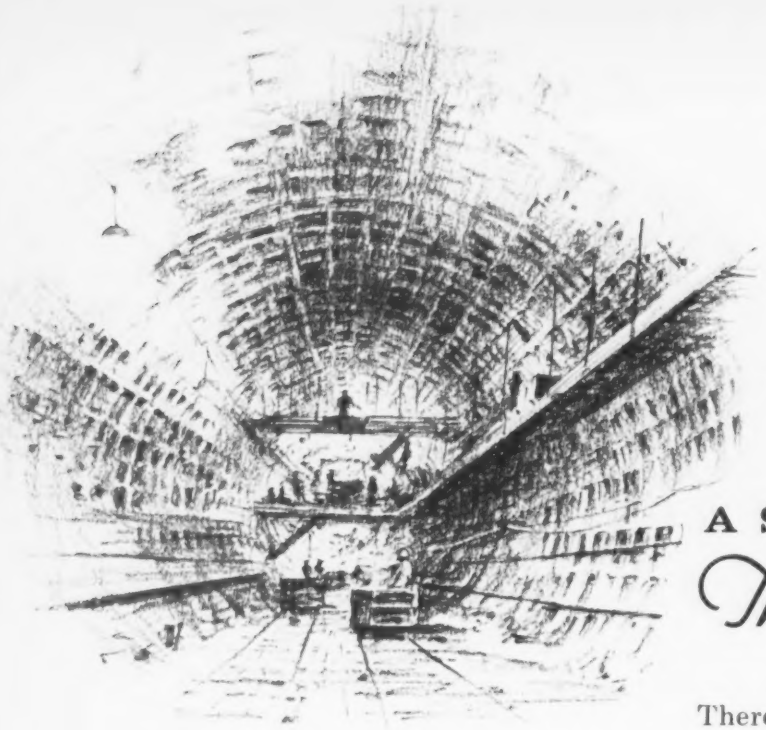
Tunneling proceeded then along a plan which protected the adjacent dam from effects of the blasting in the tunnel. The cut was line-drilled on four sides of the 19-ft. minimum width and 27-ft. height using 2½-in. holes on 4-in. centers at the top and bottom and 8-in. centers on the sides. Spacing of the drill holes was 2 by 2 ft. Blasting was begun with 2½ lb. of Gelamite 2, 1¼ by 8-in. cartridges, using three delay caps in each blast, which brought out 0.2 cu. yd. of material in the broaching shot. This was gradually increased as the tunneling proceeded until 10¾ lb. of dynamite with eight delay caps in each blast brought 2.3 cu. yd. of material. Loading was determined by proximity to the line, and the highest production reached was 1 to 1½ cu. yd. of material for 1 lb. of dynamite. At first, blasting holes were 3 ft. deep, but later went to 6 ft.

For the final advance, line-drilling went all the way through the section and the pilot hole broached through to the bulkhead void. Blast holes for this advance were drilled on 18-in. centers to within 18 in. of the upstream face. As the bulkhead was only 3½ ft. away and the dam-construction joint close by, this last blast had to be done most carefully. Only ¾ lb. of dynamite was loaded in each hole, ¾ lb. at the front or tunnel face, and ¼ lb. at the back

(Continued on page 29

A SALUTE TO *The* MOLES





A SALUTE TO *The* MOLES

There are many who build
On the face of the earth,
But of this many only a few
Tunnel under mountain and river,
Gouge deep into sand and clay
To change with daring and skill
The natural shape of the land.

These are The Moles,
A special breed of builders,
Classification—heavy construction,
With qualification based upon
Their work beneath water, rock, or soil.

The signature of their contributions
To a better life for all mankind
Is seen in mighty bridges
Spun across water barriers;
In vehicular tunnels
Under river and mountain;
And in the massive dams
Which around the earth
Have tamed unruly rivers.

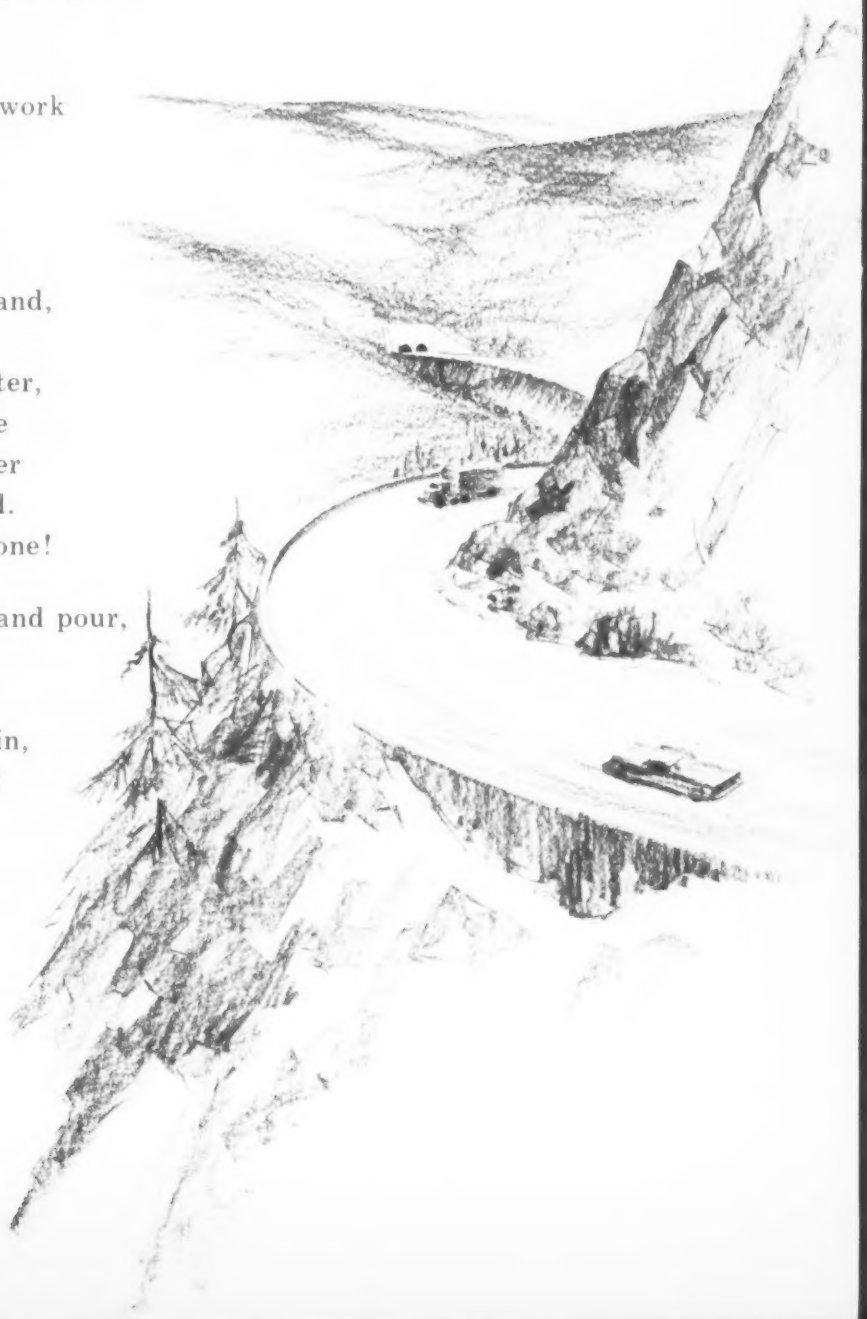
Words by Ashworth Burslem

Pictures by John Moll

These are men with determination
Made of crucible steel,
Rugged individuals
Competing no holds barred
One against the other
But close in brotherhood.
Their work is the doing
Of things undone before;
Devising gigantic machines
Some new, some grotesque hybrids
Of earlier tools
Used by builders
To bend nature's handiwork
Into a shape
Of man's desiring.

Punch a hole through
A mountain with one hand,
And with the other
Hold back rock and water,
Forever seeking to erase
This remolding of matter
Already eons unchanged.
This The Moles have done!

Drill, blast, muck out, and pour,
Or maybe Pumpcrete,
But always with
One eye on the mountain,
And the other on Time!



Turn the course of a river
Aside from its natural path
Until steel and concrete
Pile up in graceful majesty
The high head dam.
This will be the master
Of water which before
Rushed headlong to the sea,
Destructive, wasteful, wasted.
Not so since the dam
Harnessed the river
To provide electric power,
To nourish arid earth,
Or to serve a city.

Somehow the names they bear
Echo the grandeur of their existence.
There's Grand Coulee, Shasta, Boulder, and Table Rock,
Hungry Horse, Bull Shoals, and also Fort Peck,
Detroit, Flaming Gorge, Glen Canyon, and Clark Hill,
Courtright, Wishon, Brownlee, and Long Sault.
These The Moles have built!

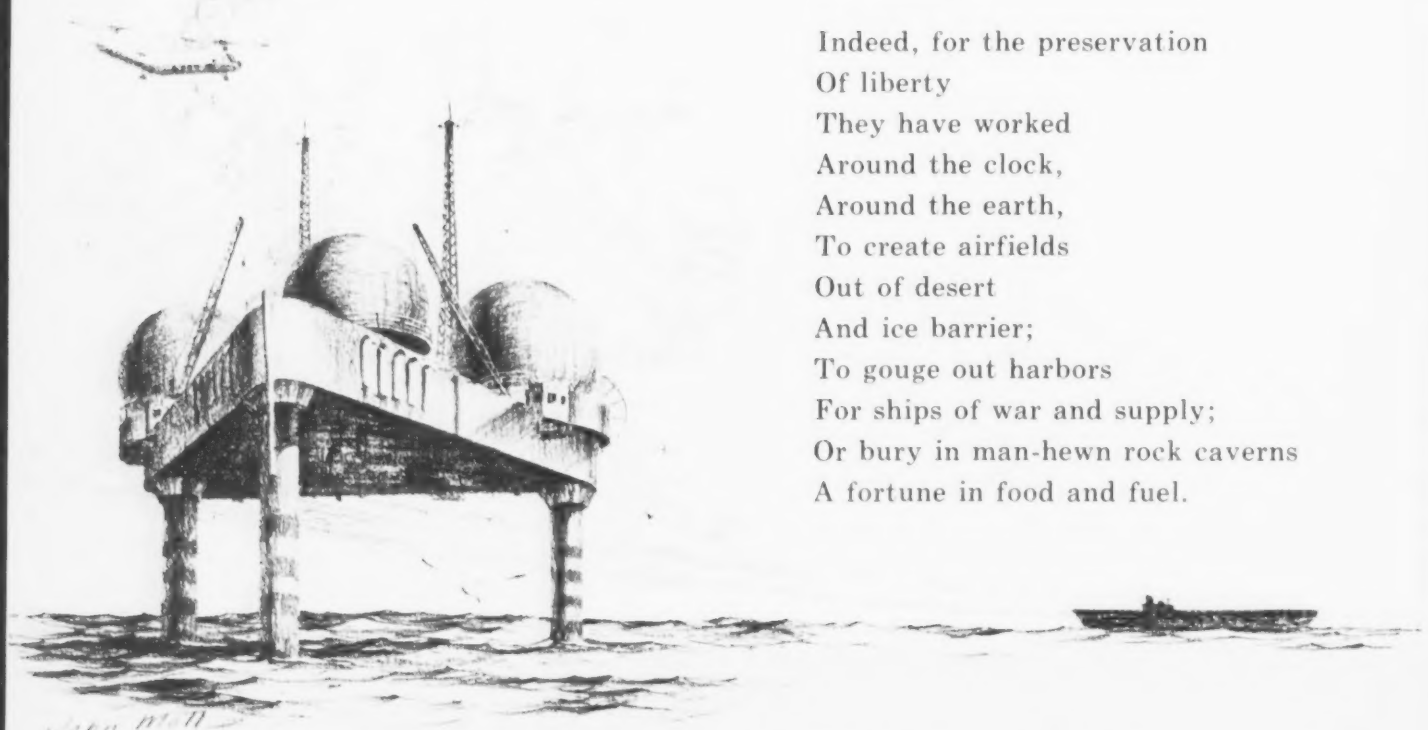
Take a giant scoop
And dig a deep hole
A city block wide,
Then sink the foundations
Of a skyscraper.
Or use a bigger scoop
To cut a hundred mile ditch,
With dams, locks, and canals,
Deep enough for ocean ships
To steam halfway
Across a continent.
These The Moles have done!

Plant the feet of a bridge
Solid and secure
Beneath water, mud, and sand.
Burrow far below a river
To push a vehicular tunnel
Between one land mass and another,
And always hold a door shut
Against tons of water overhead,
Seeking a weak spot
And sometimes
Tragically
Finding it.

This is no easy life!
There are many hazards
Routine to the work
Of The Moles,
Obstacles and challenges
Which must be
And are
Mastered.
For these are men
Who wrestle the elements
To a fall.

Take the Texas towers.
The Moles were ordered
To anchor an electronic island
Housing almost a hundred men
On the turbulent Atlantic.
This time they built
From the top down
Not from bottom up.
They drove legs of steel
Into the ocean's depths
Ready for any wave or wind,
To create offshore sentries
For defense.

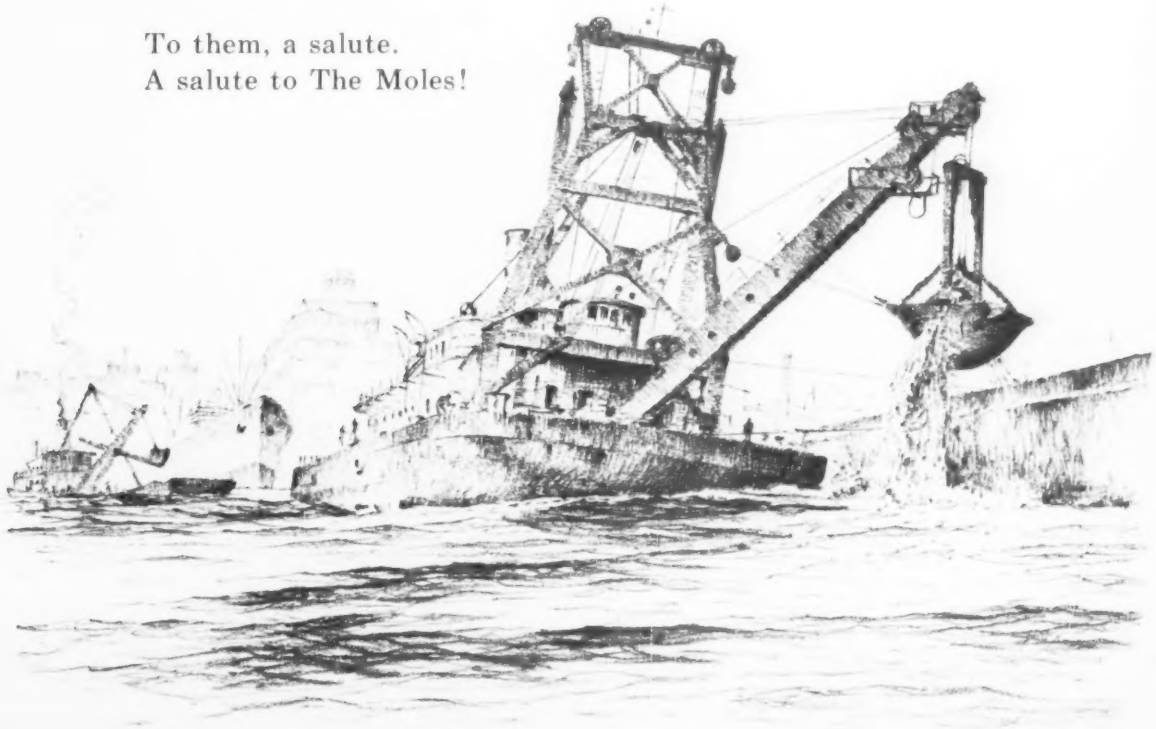
Indeed, for the preservation
Of liberty
They have worked
Around the clock,
Around the earth,
To create airfields
Out of desert
And ice barrier;
To gouge out harbors
For ships of war and supply;
Or bury in man-hewn rock caverns
A fortune in food and fuel.



All of these things
The Moles have achieved,
While refusing to recognize the phrase—
It can't be done!

There are many who build
On the face of the earth.
But only a few,
An exclusive, adventuring,
Hardy few
Tunnel under water, rock, and soil
To construct monuments
Designed to last forever
In the service
Of mankind.

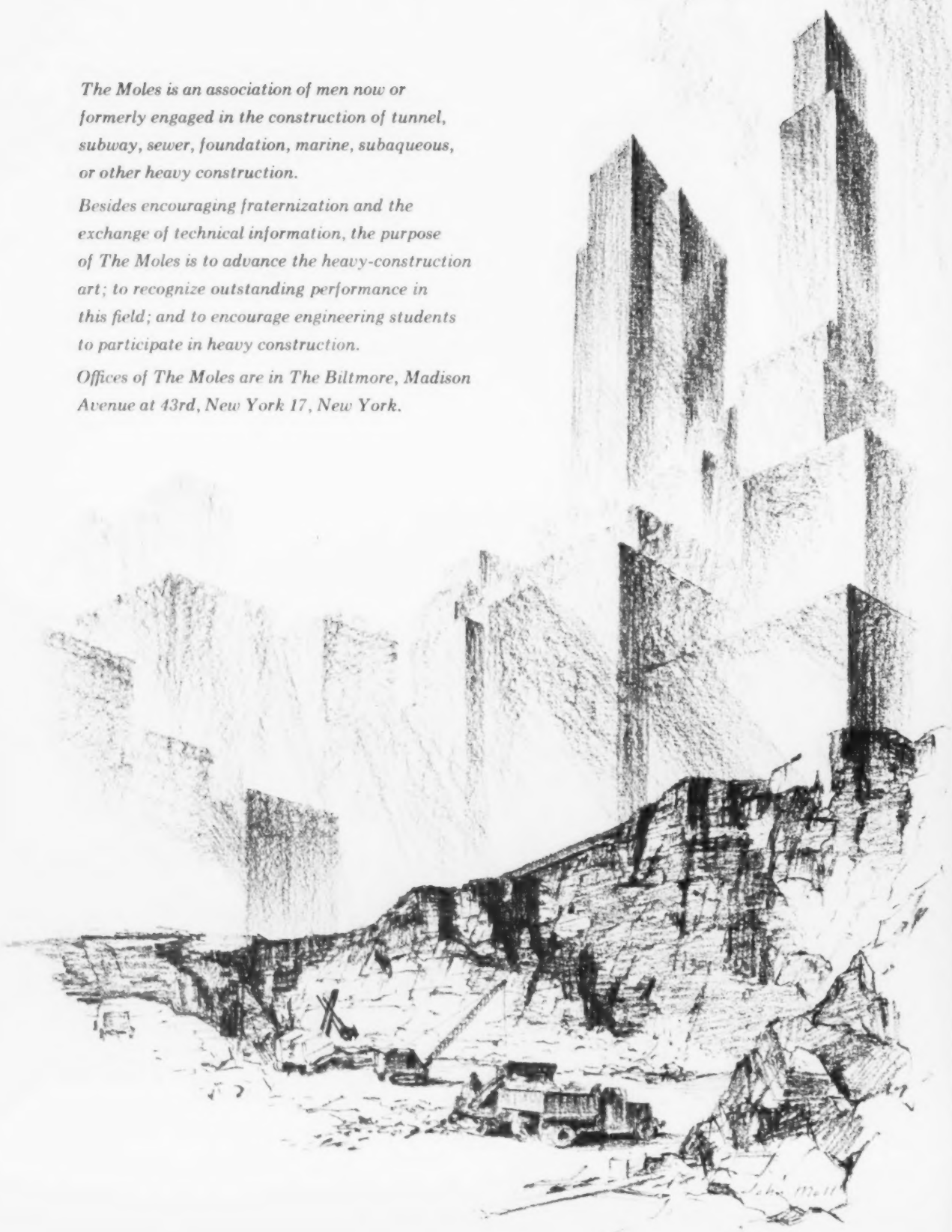
To them, a salute.
A salute to The Moles!



The Moles is an association of men now or formerly engaged in the construction of tunnel, subway, sewer, foundation, marine, subaqueous, or other heavy construction.

Besides encouraging fraternization and the exchange of technical information, the purpose of The Moles is to advance the heavy-construction art; to recognize outstanding performance in this field; and to encourage engineering students to participate in heavy construction.

Offices of The Moles are in The Biltmore, Madison Avenue at 43rd, New York 17, New York.



Chute-des-Passes
A Gigantic Construction Project

Engineering skill and ingenuity combine to speed completion of tunnels and underground facilities for a new 1,000,000-hp. hydroelectric plant in northern Quebec

ROBERT E. DYMENT°

THREE HUNDRED miles north of Quebec City at Chute-des-Passes, Province of Quebec, Canada, a tremendous underground powerhouse is being constructed along with nearly 10 miles of tunnels. When completed, this powerhouse will headquarter generating equipment capable of providing 1,000,000 hp. of electrical energy.

The project is under construction for Alcan, the operating company of Aluminium Limited and is located near the Peribonka River in the heart of the rugged bush country of Quebec. The major items of underground work specified by the contract are the driving of a 6-mile 34-ft.-diameter tunnel, removal of rock to make an underground chamber 465 by 70 by 70 ft. to house the hydroelectric units, construction of a tailrace manifold chamber of about the same dimensions, and driving a 9,000-ft.-long 48-ft.-diameter unlined tailrace tunnel. The chambers and tunnels are being hewn out of granite of the Laurentian shield. The work is being done to supply the electric power necessary for aluminum smelting processes at Isle Maligne, Quebec, 100 miles to the south. The five 200,000-hp. generators to be installed in the underground chamber are considered the largest units of their kind in the world. To give a better idea of the immensity of the underground work, the 34-ft.-diameter main supply tunnel is larger than the Holland Tunnel which speeds traffic between New Jersey and New York. The main powerhouse is about as high as a ten-story building.

Water will flow through the tunnel at a rate of 18,000 cu. ft. per second and then drop almost 636 ft. vertically to the powerhouse. At the powerhouse, the five generators will be able to produce a total of 1,000,000 hp. The electricity will then be carried on 330,000-volt transmission lines to Isle Maligne.

°82 E. Fifth Street
Dunkirk, New York

TUNNEL HEADING This tunnel, when completed, will be four times the length of the Holland Tunnel between New York and New Jersey. Workers are shown installing the ventilation pipes to provide the fresh air for the health and comfort of the men underground.

PROJECT AREA: It is at Chute-des-Passes in northern Quebec that Alcan is engaged in a gigantic hydroelectric construction project. The five underground generators to be installed will add 1,000,000 more horsepower of electrical energy to meet the needs of an expanding aluminum industry.

Work Progressing Rapidly

Perini Quebec, Inc., is the sponsoring contractor for the joint venture of Perini-McNamara-Quemont Construction Company. Work was started on the project in September, 1956, and the engineers in charge of the job estimate that completion date will be early in 1960. When the construction work is completed, Chute-des-Passes' power-producing facilities will give Aluminium Limited a total of 4,780,000 hp. for producing electricity in Canada. Aluminium Limited is the same company that built the vast subterranean hydroelectric power plant for its aluminum facilities at Kitimat, British Columbia. It is estimated that about 15% of all primary aluminum used in the United States is produced in Canada.

Access tunnels, or adits, were begun at three points along the route of the main tunnel. The main tunnel will run from a storage lake to the subterranean powerhouse 6 miles downstream on the Peribonka River. Adit No. 1 is 2,078 ft., Adit No. 2 is 4,021 ft., while Adit No. 3 is 2,675 ft. long. Basically, they are sloping access bores to the power tunnel. The main tunnel is 34 ft. in diameter. Contractors have already completed all three of the tunnel adits and are now excavating the main tunnel and powerhouse caverns. It is expected that these two units will be completed by August, 1959.

With construction work going on around the clock, tunnel crews have been working two 12-hour shifts and are setting records for advance. As much as 6,500 cu. yd. of rock a week

(Top)

RUGGED TERRAIN: The Peribonka River, one of the routes used by the eighteenth- and nineteenth-century French explorers, is the site of the Chute-des-Passes project. The underground powerhouse will be built under the cleared area shown in the lower right of this aerial photograph.

(Center)

A SPECIAL JUMBO: Not only is the most modern standard equipment used throughout the project, but special apparatus is designed and built on the site. The three-tiered jumbo is being built and tested in the outside work area to meet special needs of the big tunnel.

(Bottom)

AT THE FACE: The jumbo at the face of the discharge tunnel is equipped with 20 Joy TM 400 drills mounted on hydraulic booms. Working the top heading only, excavation averages 33 cu. yd. per ft. of advance.

has been removed from each of the tunnel headings. The top heading and bench method are used in driving the tunnel.

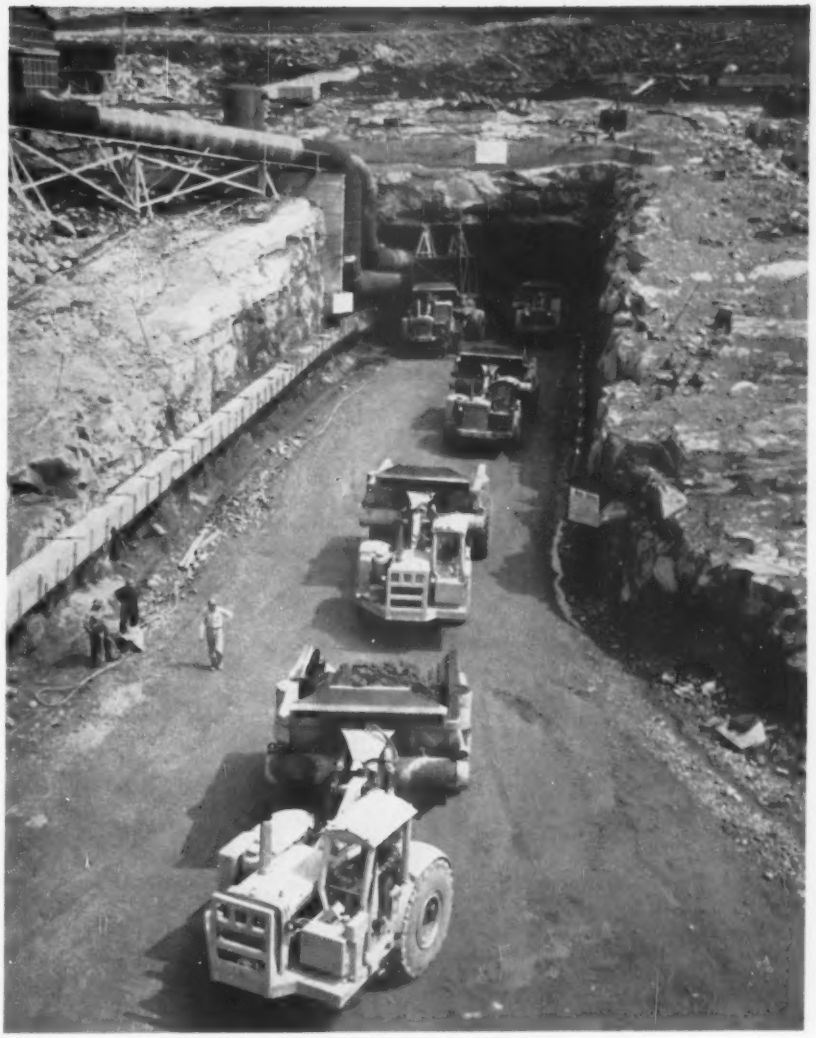
Drilling and Blasting

The most modern construction techniques are being used in speeding this project to completion. Drillers on three-tiered specially designed and constructed jumbos drill holes in the heading in record time for the blasting crews. All jumbos are equipped with Joy TM 400 drills mounted on hydraulic booms. Timken carbide detachable bits, 2¼ in. in diameter, used with Atlas-Ottawa 1¼-in. drill steel are giving satisfactory footage in the granite before having to be replaced.

A special jumbo, skid mounted, was built on the job site for use in driving the 48-ft.-diameter tailrace tunnel. This jumbo, after being built and tested outside, had to be partially dismantled and dragged into the tunnel heading where it was reassembled and is now in operation. Its 20 drills are on three levels, six on each platform and two on the top for drilling holes for roof bolts. The top heading is drilled and blasted first. Drill holes are 2¼ in. in diameter and are loaded with ten cartridges of 40% gelatin extra dynamite. The bench section is then blasted, using vertical drill holes. The excavation averages 33 cu. yd. per ft. of advance. Progress will be faster when drilling and blasting in the bench since only 15 cu. yd. per ft. of advance is contemplated. It was only after considerable experimenting with both horizontal and vertical holes that it was decided the vertical holes were more efficient for removing the bench.

The intake end of the main tunnel is approximately 140 ft. below the surface of Lake Peribonka and extends about 600 ft. under the lake. A 50-ft. "plug" of rock keeps the water of the lake from rushing into the tunnel. Perhaps one of the most delicate blasting operations of the whole project will be the removal of this plug by a single blast, so that the water will flow through the tunnel and into the generating units.

Based on the type of rock and the blasting results to date, it is estimated that a total of 10,000,000 lb. of dynamite will be used before this project is completed. Approximately 500,000 lb. of 40% gelatin extra dynamite is now being used each month. At this rate of dynamite consumption, the Chute-des-Passes project is considered by many to be the major user of explosives in Canada.



REAR-DUMP TRAILERS: A fleet of 33 rear-dump trailers, pulled by Caterpillar DW 21's, is kept busy hauling the muck out of Adit No. 1. These units have a capacity of 19 cu. yd. and are highly maneuverable.

Equipment

With the exception of six portable 600-c.f.m. Ingersoll-Rand and Gardner-Denver compressors, all the compressed air on the job is being supplied by Joy Manufacturing Company's Model WN 102, 720-c.f.m. compressors.

The blasted material in the tunnel is being loaded by Northwest shovels equipped with 1½-cu. yd. dippers. These units have been modified by having their booms and sticks shortened for ease of handling underground. The muck is loaded into Athey PR 21 trailer units and hauled by Caterpillar DW 21 tractors to the spoil piles.

Some of the principal operating equipment used on the job are Northwest Models 6, 25, 41, and 80D shovels, Caterpillar DW 21 and D 8 tractors and Model 12 graders, Athey PR 21 haul truck units, Joy Manufacturing Company TM 400 compressors and W 102 drills and fans, Ingersoll-Rand and Fairbanks-Morse pumps, Mack trucks, and Ford service vehicles.

At the peak of activity more than 3,000 men were working on the job from camps located at each of the ac-

cess tunnels. Now that the preliminary work is done the crew has been reduced and there are about 1,500 men currently employed in the construction work at this rugged northern Quebec location.

Modern Community

As it has done at Kitimat, British Columbia, and at plant sites in other parts of the world where it has built aluminum-producing installations, Aluminium Limited is building a new community for the permanent staff near the location of the powerhouse. The town will sit high on a hill overlooking the Peribonka River and will be a modern community in every respect.

Already the first permanent homes for the staff have been built. In addition to the modern domiciles, the town will provide the employes with up-to-date stores, a school with a large gymnasium that will also be used as a hall for community activities. Every effort is being put forth to assure the comfort and welfare of the staff. Approximately 50 families, composed of operating and maintenance staff, will be permanently located here after the completion of the construction program.

The project manager for this huge engineering program is E. B. Fontaine. Project engineer is J. A. Bedington. Job superintendents are C. West, M. G. Brown, and U. S. Hodgins, while R. Anderson is equipment superintendent. Administrative officer for the owner is J. W. Liddle; resident engineer is A. Moffatt; executive officer for the owner, G. Proulx; and D. C. Cannon is the executive officer.

(Top)

MUCKING: The blasted rock in the heading is loaded by Northwest shovels equipped with 1½-cu. yd. dippers. Booms and sticks of these shovels have been shortened for ease of handling underground.

(Center)

ROOF SUPPORTS: In some sections of the tunnels, roof supports were necessary, although the rock is generally a good quality solid granite of Laurentian shield.

(Bottom)

A WORKHORSE: These "Big Cats," more formally known as DW 21's, proved faithful workhorses in hauling the muck from the underground workings to the spoil area.

California's Carquinez Bridge Freeway Project

Huge cuts through hills and a new bridge spanning Carquinez Straits are features of freeway designed to relieve traffic bottleneck on U. S. Route 40 northeast of San Francisco

DAVID B. JACOBSON*

CONTRACTORS working for the California Division of Highways made, and are still making, history as they add a second span to the present three-lane Carquinez Bridge and relocate 7.9 miles of adjacent freeway in order to relieve one of California's worst traffic bottlenecks. The project is located about 40 miles northeast of San Francisco, where trucks and passenger vehicles twist and curve through steep hills as they follow U. S. Highway 40—the chief link between the State's largest northern city and its capital at Sacramento—to the narrow 31-year-old span that crosses the Carquinez Straits.

Financed for the most part by a $46,000,000 bond issue, the vast con-

*1482 University Avenue
Berkeley 2, California

THE BIG CUT: This man-made canyon is a ¼ mile wide at the top and more than 300 ft. deep at it deepest point. A total of 8½ million cu. yd. of earth was excavated, making this the biggest highway cut in the United States.

CARQUINEZ BRIDGE: Part of the California State Highway's plan to relieve the traffic bottleneck on U. S. 40 is to add a second span to the present three-lane bridge crossing Carquinez Straits.

struction project began in 1956 and will involve, in total, six major contracts. The American Bridge Company, a division of United States Steel, is building the superstructure for the bridge on a $9,489,126 contract, the largest single award ever granted by the Division of Highways.

The double-cantilever bridge, which will include two 500-ft. end anchor spans and two center spans of 1,100 ft. each, is now in its final stages.

Under a $5,500,000 contract for the substructure, Mason & Hanger, Silas Mason Company, Inc., and F. S. Rolandi, Jr., Inc., plunged three giant caissons, 102½ ft. long and 53 ft. wide, to bedrock 135 ft. below the water surface in the Carquinez Straits.

The approaches and interchange at the southern approach to the bridge were awarded on a $4,600,000 contract to Peter Kiewit Sons' Company. The Kiewit organization built 50 piers, the tallest one being 106 ft., making use of a slip-form technique for the first time in any of the 11 Western States.

Rothschild, Raffin and Weirick of San Francisco has been allocated $1,125,858 for grading, surfacing, and widening the approach.

Two Major Highways

In addition to the building of the bridge, the Carquinez Project calls for two major highway-construction jobs. To the south of the straits McCammon-Wunderlich Company and Wunderlich Corporation have completed 4.9 miles of freeway, financed by state gasoline tax money. The contract involved moving 4,300,000 cu. yd. of material, including a single cut of 1,850,000 cu. yd.

Between the McCammon-Wunderlich job and the bridge, the Ferry and Crow Construction Company of Glendale, California, was allocated $7,834,263 for 2.887 miles of freeway construction, including grading, paving, and overstructures. Part of the work was the moving of 8,500,000 cu. yd. of roadway excavation 8,000 ft., one of the greatest earth-moving jobs in history. The concrete overstructures and 28,500 cu. yd. of pavement have been subcontracted to Gordon H. Ball, Inc., of Danville, California.

"Big Cut"

In spite of the striking contrast between the old and the new bridge, a sight which can be viewed more readily as the new structure takes shape, the freeway section of the Carquinez Project is the more famous. Its "Big Cut" excavation, a quarter of a mile wide, 300 ft. deep at its deepest point, and requiring the excavation of 8½ million cu. yd. of earth, seems destined to become a landmark for tourists—a man-made canyon.

Besides Big Cut, the Ferry and Crow job included two additional excavations, one of 800,000 cu. yd. and the other of 625,000 cu. yd. Because much of the material taken from Big Cut had to be hauled 7,000 to 9,000 ft. through

an adjacent cut to the disposal area, an enormous amount of overhaul resulted, in excess of 455,000,000 station yd.

Construction Features

From a contractor's standpoint, one of the most interesting features of the Big Cut project was the use of teams of scrapers hauled in tandem. Each team consisted of a Le Tourneau-Westinghouse RU pulled by a Caterpillar DW20, and the project marks the first large-scale use of tandem rubber-tired scrapers. Despite the age of the Le Tourneaus—some of them were 12 years old—they took the strain well and the equipment attained speeds up to 40 m.p.h.

Ferry and Crow leveled the haul road by means of a specially designed landplane. The smooth-surfaced haul road reduced wear on the equipment, fuel consumption, and downtime, so that Ferry and Crow ordered the modified agricultural land leveler at a cost of $6,000 from the Marvin Landplant Company of Woodland, California.

The Ferry and Crow landplane is 50 ft. shorter than the 80-ft. farm model and, therefore, has greater maneuverability. In addition, it was strengthened in order to take the rougher treatment required by construction work. A Euclid tractor equipped with rubber tires pulled it at speeds ranging from 5 to 15 m.p.h.

Blasting

Although the bulk of the excavation on Ferry and Crow's project was located in the Big Cut where explosives were required only to break up an occasional boulder, greater use of explosives was required to facilitate the excavation on an adjacent cut through which part of the Big Cut yardage had to be hauled.

The formation on this cut consisted of hard lenses of gray Franciscan sandstone which was drilled with wagon drills using carbide bits. Because of the various sizes of the lenses of hard sandstone it was difficult to standardize on a drill pattern, or do much development work ahead of the excavation, although an average pattern of 6 to 8 ft. in depth, using a 2½-in.-diameter drill hole, was found to produce the best results.

Because of the presence of water in the drill hole, Gelamite® 2 was used. Approximately ¾ lb. of Gelamite to a cu. yd. of material was loaded. There was little delay in drilling and blasting operations; however, at times overhead high-voltage power lines demanded very careful blasting. A Northwest 80-D shovel was employed to load the blasted material into end-dump trucks for delivery to the filled area.

NEARING COMPLETION: Within a short time motor traffic between San Francisco and Sacramento will speed along a modern highway that has eliminated the twisting and steep hill that caused many traffic jams.

Personnel

All work on the Ferry and Crow project is expected to be finished by April, 1959. Key personnel include B. W. Booker, assistant highway engineer of District 4, who is in charge of the freeway south of the bridge; L. A. Weymouth, district engineer of operations; Vincent Smith, construction engineer; Charles P. Sweet, Jr., resident engineer on the Ferry and Crow job. R. C. Philbert, Norman Gilliam, Leland "Babe" Crow, and Pat Ferry are the superintendents of the Ferry and Crow construction.

TANDEM SCRAPING: An unusual and interesting procedure was the use of scrapers working in tandem. A rubber-tired Caterpillar DW20 pulls the scrapers. The rear scraper is operated by an overhead cable system.

THE BEAVERS AWARDS

Eight men are honored for their outstanding contributions to the heavy-construction industry west of the Mississippi

H. E. CARLETON

OSCAR McCORMICK

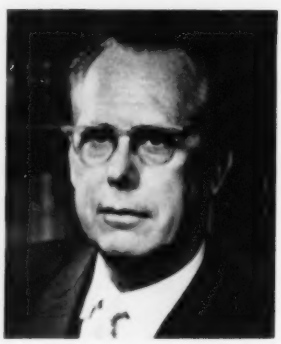
JOHN MacLEOD

L. J. SVERDRUP

L. E. DIXON

CHARLES P. DUNN

BEN MOREELL



JAMES L. LOVELL

Approximately 1,000 members and guests of the Beavers, an organization of men engaged in the heavy-construction industry west of the Mississippi, attended the Fourth Annual Beavers Award dinner held at the Biltmore Hotel in Los Angeles on January 15. Each year the Beavers pay tribute to those men who, by their skill, responsibility, and integrity, have distinguished themselves by their contributions to the heavy-construction industry.

The highlight of the evening's activities was the awarding of the coveted "Golden Beaver" to eight recipients. John M. Sawyer, president of the Beavers, presided at the ceremony.

The men chosen to receive the awards and their fields of activity are listed below.

Management: L. E. Dixon, L. E. Dixon Company; John MacLeod, Macco Corporation. Engineering: Charles P. Dunn, International Engineering Company; L. J. Sverdrup, Sverdrup and Parcel, Inc. Supervision: H. E. Carleton, A. M. Coker Construction Company; O. S. McCormick, Al Johnson Construction Company. Supply: James L. Lovell, E. I. du Pont de Nemours & Company. Special: Ben Moreell, Jones & Laughlin Steel Corporation.

Delicate Blasting on Wilson Dam

(Continued from page 12)

of each hole, to pull the section to the pilot hole. The remaining concrete was chipped out.

Another Critical Job

Cutting through the old roadway arches and piers in the new lock area is another critical blasting job, currently under way, which had been held back until the four-month period when the roadway over the dam would be closed to highway traffic for the erection of the high-level bridge. Four roadway arches weighing 6,320 tons, and three piers weighing 1,380 tons must be cut out, loaded on barges, and dumped upstream in Lake Wilson. While the roadway was still in use 16 ft. of the arches on the downstream side was removed, reducing the traffic to one lane.

As bays 3, 4, 5, and 6 were to be removed, blasting was begun in bay No. 5 to permit a careful check of arches Nos. 4 and 6 to determine what if any damage had been caused. Damage to these bays would not matter because they were to be removed, but would provide a check on the procedures. A typical shot on the arches and piers removed a section 4 by 8 ft. which had been outlined by line-drilling. Holes were drilled on 2 by 2-ft. centers and loaded with Gelamite 2, 1¼ by 8-in. cartridges, the load ranging from ½ to 1 cartridge or from 0.2 to 0.4 lb. of dynamite per hole. On each shot, falling-pin tests on the sidewalk above the arch are made and recorded to keep an accurate record of vibration felt on each blast.

TVA originally planned to remove the gate section, the roadway arch and piers in the wet, but the TVA Construction Plant Branch devised a plan for their removal in the dry using the permanent spillway and the temporary culvert bulkheads.

Results obtained on the cutting-through of the old dam may determine, in part, TVA plans for other Tennessee River lock installations.

The changes being made at the Wilson Dam will mean a marked improvement in the river traffic bottleneck which had developed at the lock. The single lift will provide faster locking through and make unnecessary much of the breaking up of large tows to be locked through in two sections. The straightening of the approaches to the lock will be a boon to pilots who have had to twist long tows around relatively sharp bends, and will further expedite the traffic.

For the Tennessee Valley Authority, work on the dam has been under the supervision of George K. Leonard, chief engineer, Knoxville; Henry T. Lofft, chief construction engineer, Knoxville; R. A. Monroe, chief of Design Branch, Knoxville. At the Wilson Dam, Warren McMahan is project manager; H. L. Broadfoot, construction engineer; and John C. McCraw, construction superintendent.

FLOATING BULKHEAD: TVA engineers maneuver floating bulkhead into position on the upstream side of Wilson Dam in preparation for driving intake culvert tunnels. Bulkhead has been partially flooded, tipped to vertical position, and is being trimmed to the face.

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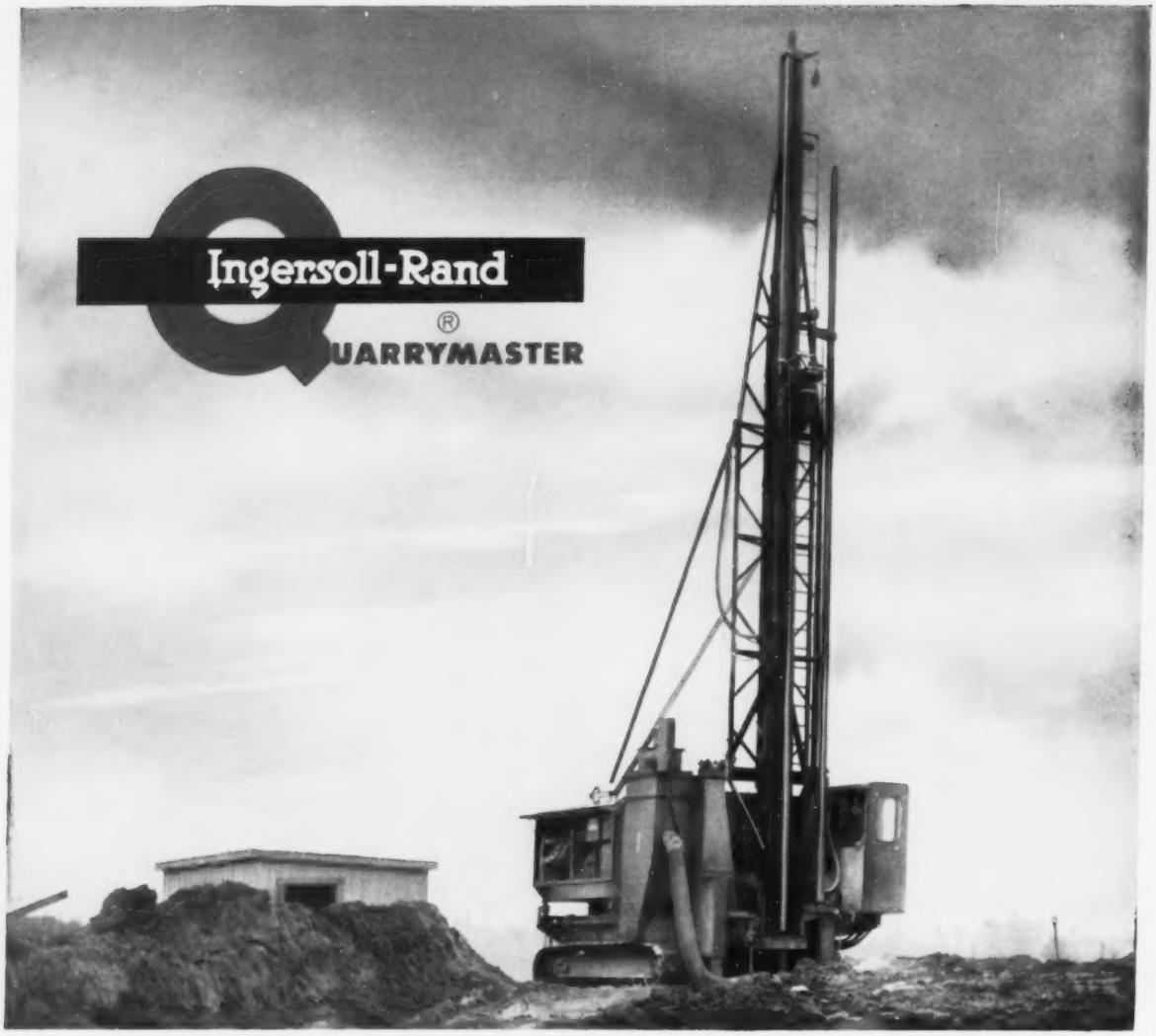

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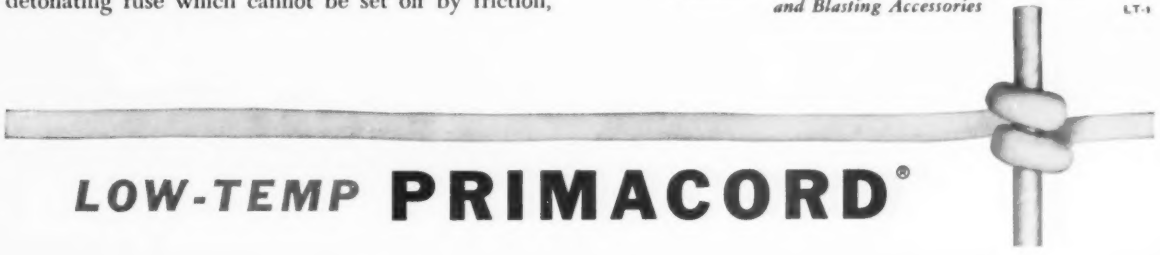

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